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(54) **Electret device**

(57) An electret device 10 comprises negatively and positively polarised electret elements (14, 12) which are stacked with each other. At least one outer end of the electret device provides a conductive electrode by means of a conductive layer (24 or 22) of an electret element itself or a conductive outer plate (28 or 26) stacked on a dielectric layer (20 or 18) of an electret element.

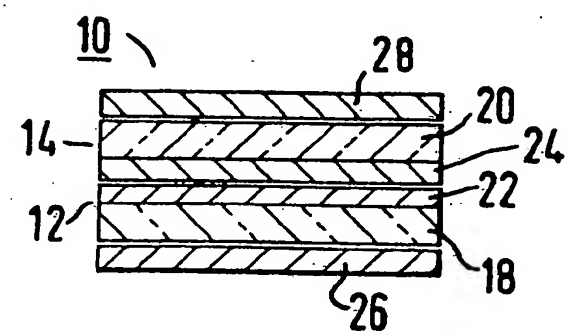

FIG. 2

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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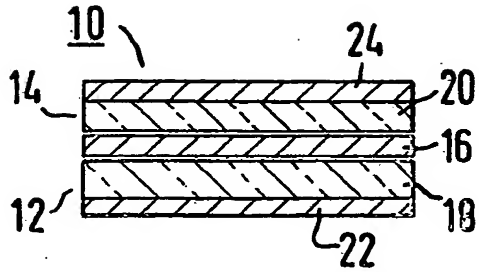


FIG.1

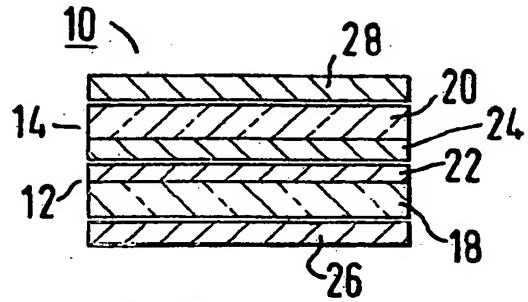


FIG.2

FIG.3

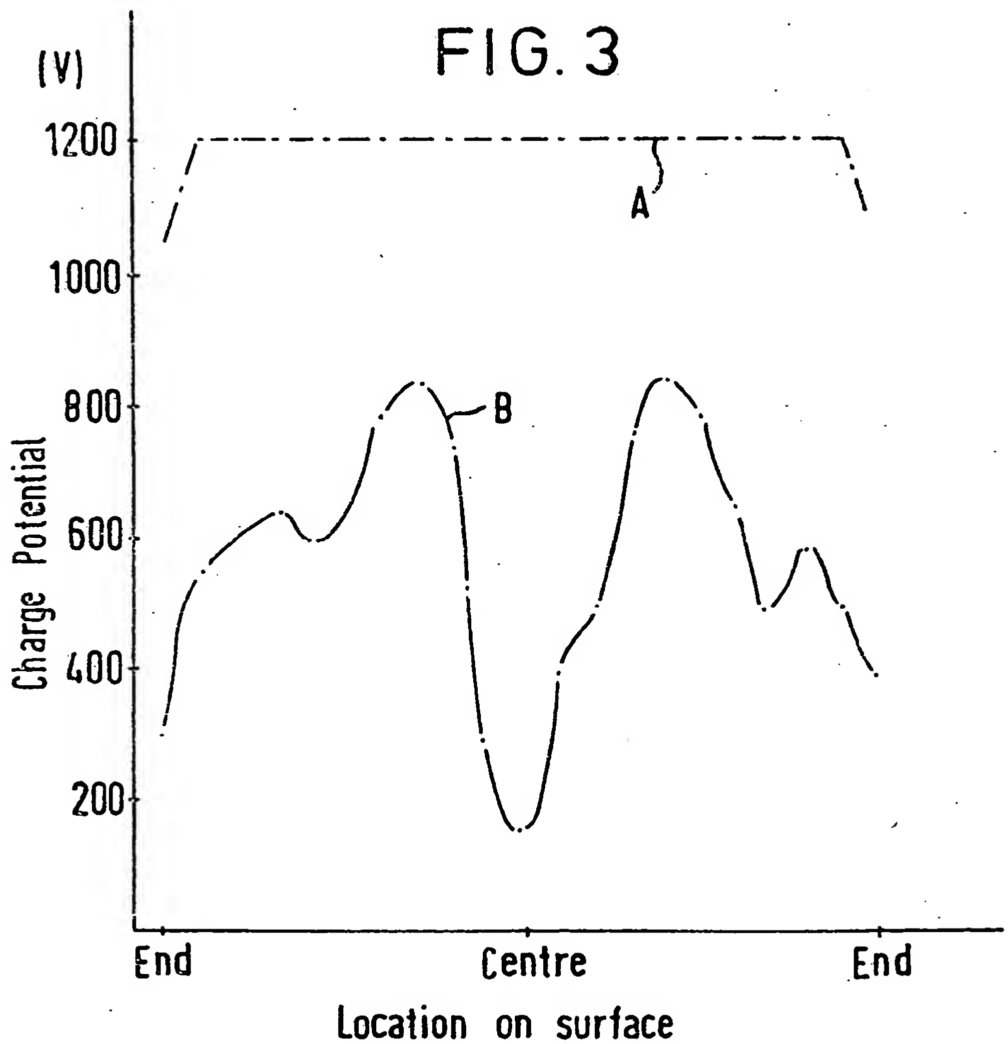


FIG. 4

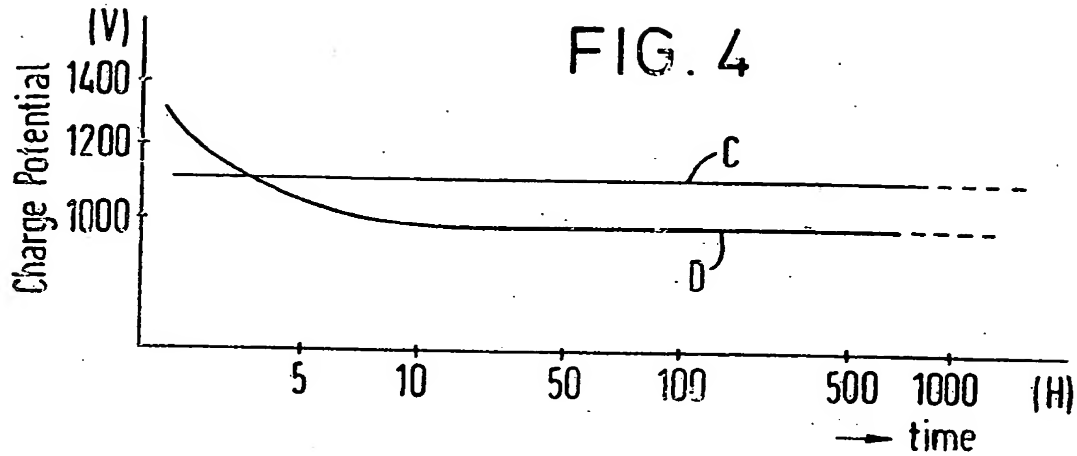
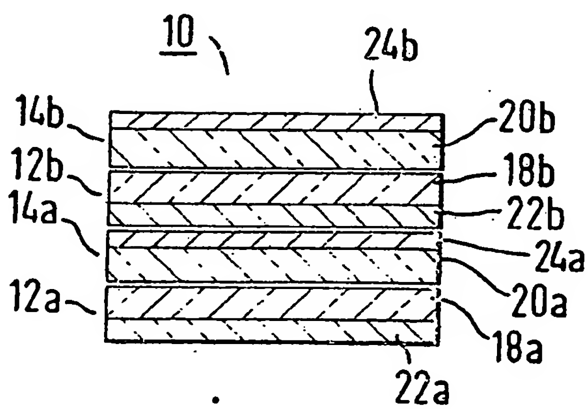

(V)
1400
1200
1000
Charge Potential
C
D
5
10
50
100
500
1000
(H)
time

FIG. 5


10
24b
14b
20b
12b
18b
14a
22b
24a
20a
12a
18a
22a

SPECIFICATION

Electret d vice

This invention relates to an electret device.

An electret is a dielectric body which is provided with a volume of surface electric charge. The electret dielectric body retains the electric charge for a very long time, often measured in tens of years. The electric charge, or the dielectric polarization, is achieved, for example in one process, by heating a body of dielectric material to a relatively high temperature while the material is exposed to an intense electric field for a substantial time and then cooling the material while maintaining its exposure to the electric field. Upon cooling, the material exhibits characteristics of a permanent charge distribution.

Electrets have many uses as transducers such as microphones, loudspeakers or record-disc pick-ups. Moreover, electrets are hoped to be used as memories, high potential sources, measuring apparatus and other devices in the near future.

Electrets are dielectrics which produce static electric fields having a relatively long lifetime. Their long lifetimes are mainly attributable to the development of new materials which are more stable than the earlier employed waxes. Today, plastics materials such as polyethylene, polypropylene, polyethylene terephthalate are extensively used to form electrets.

Conventionally, electrets are used in the form of electret devices of which an electret body is secured on a conductive electrode. These electret devices have drawbacks in that the surface charge potential is relatively low.

According to the present invention from one aspect, there is provided an electret device comprising:

a first electret element comprising a negatively polarized dielectric layer and a conductive layer; and

a second electret element comprising a positively polarized dielectric layer and a conductive layer, which second electret element is stacked with said first electret element with the dielectric layers facing each other.

According to the present invention from another aspect, there is provided an electret device, characterised in that it comprises:

a first electret element comprising a negatively polarized dielectric layer and a conductive layer;

a second electret element comprising a positiv ly polarized dielectric layer and a conductive lay r, which second el ctret el ment is stacked with said first electret element with th conductive layers facing each other directly; and

outer plates stacked on said first and second electret elements respectively, in which at least on of the out r plates comprises conductive material.

The present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of an embodiment of an electret device according to the present invention;

Figure 2 is a sectional view of another embodiment of an electret device according to the present invention;

Figure 3 shows graphs illustrating charg potential distributions on electret devices;

Figure 4 shows graphs illustrating charge retention properties of the electret devices according to the embodiments; and

Figure 5 is a sectional view of a modified embodiment of an electret device according to the present invention.

Throughout the drawings, like referenc numerals will be used to designate like or equivalent portions.

Fig. 1 shows a sectional view of an electret device 10 which comprises two electret elements 12 and 14 which are stacked with each other via an intermediate plate 16. Each of electret elements 12, 14 has a respective one of dielectric layers 18, 20 each facing the intermediate plate 16, and a respective one of conductive layers 22, 24. Each dielectric layer 18, 20 is provided with a volume of electric charge or polarization. That is, dielectric layers 18 and 20 are so-called electrets. However, each of dielectric layers 18, 20 has a different polarity charge from the other. For example, the dielectric layer 18 has positive charges and the other dielectric layer 20 has negative charges. Intermediate plate 16 is formed of a conductive, non-conductive or semi-conductive material.

In the electret device 10 of Fig. 1, many negative charges arise on an outer surface of the electret element 14 or the outer surface f the conductive layer 24, caused by dielectric polarizations of both the dielectric layer 20 of electret element 14 itself and the diel ctric layer 18 of the other electret element 12. Therefore, electret device 10 has a high surface charge potential, nearly two tim s of that of an individual one of electret elements 12, 14.

The charge potential E_s is assumed to b given by equation (1):

$$E_s = K.(E_{14} - E_{12}) \qquad (1)$$

where E_s represents the charge potential of electret device 10 as a whole, E_{14} and E_{12} represent the average charge potentials of electret elements 14 and 12 respectively, and K r pr sents the polarization constant, as it may be called, of the mat rial of intermediat plate 16.

The constant K of metal is a numerical value between about 0.6 and 0.99, and the constant K of glass is around 0.83, in our measurements.

Assuming the charge potentials E_{14} and E_{12} are almost the same in their absolute values and represented as E, equation (1) may be written as the following equation (2).

$$E_s = 2.K.E \qquad (2)$$

Individual electret elements 12 and 14 are each similar to a conventional electret device.

Usually, polarization of each of dielectric layers 18, 20 is carried out by, for example, imposing an electrical field or applying charged particles like ions, before or after the respective one of conductive layers 22, 24 is combined with the dielectric layer. The polarity of the dielectric layer 18 or 20 may be decided by the polarity of the electrical field or the charged particles.

Almost all dielectric materials suitable for an electret may be adopted for dielectric layers 18 and 20. High molecular weight compounds like polypropylene, fluorine—containing polyolefins (such as polytetrafluoroethylene) or polyethylene are, however, especially suitable because the electric charge in those materials becomes relatively high in potential and is maintained for a long time.

As is apparent from the equation (1) or (2), the charge potential E_s of the electret device 10 is exceedingly higher than that of each of the individual electret elements 12 and 14. Therefore, the electret device 10 described above is very useful for many fields. For example, an electrostatic transducer like a microphone or a headphone using the electret device 10 becomes highly sensitive and has other effective properties. Especially, a powerful electrostatic loudspeaker which was difficult to realize is easily obtained by using the electret device 10.

Fig. 2 shows a sectional view of an electret device 10 of another embodiment according to the present invention. Electret device 10 of Fig. 2 also comprises two electret elements 12 and 14 which are stacked with each other. Each of electret elements 12, 14 also has a respective one of dielectric layers 18, 20 each separate from the other, and conductive layers 22, 24 each facing the other directly. On dielectric layers 18 and 20, two outer plates 26 and 28 are stacked respectively. At least one outer plate, for example 26, is formed of conductive material for use as a conductive electrode of the electret device 10. On the other hand, the other outer plate may be made of a conductive, non-conductive or semi-conductive material.

Fig. 3 shows graphs comparatively illustrating potential distribution characteristics on an electret device 10 and a conventional electret device, the charge potential in volts (V) being plotted against location on the upper surface, starting at one nd and finishing at the opposite end. Graph A is a potential distribution characteristic of an electret device 10 of Fig. 1 or Fig. 2, and graph B is a potential distribution characteristic of a conventional electret device similar in its size with that of device 10.

As is seen from graph A, the charge potential of an electret device 10 is nearly two times of that of a conventional electret device as shown by graph B. The charge potential of graph A has little dispersion. As will be understood from the very flat characteristics of graph A, an electret device 10 has exceedingly uniform surface charge at every part of the upper surface of electret device 10. On the other hand, a conventional electret device described above does not have a uniform surface charge as will be understood from graph B.

An electret device 10 therefore, provides a very good usefulness. That is, for example, transducers using an electret device 10 may provide high-efficiency transducing characteristics due to the high-surface charge potential of the electret device 10.

Furthermore, transducers using an electret device 10 may provide high-fidelity transducing characteristics because the electrostatic forces arising between an electret device 10 as one electrode of a transducing capacitor and an opposite electrode are uniform at every part of the transducing capacitor.

An electret device 10 is provided with long-lived charge or polarization retention properties because dielectric layers 18 and 20 are protected from being exposed to the air, and the charge becomes hard to drain away from dielectric layers 18 and 20. Thus, dielectric layers 18 and 20 of electret elements 12 and 14 are protected from being exposed to the air by conductive layers 22 and 24 (Fig. 1) or outer plates 26 and 28 (Fig. 2), and the charge becomes hard to drain away from dielectric layers 18 and 20.

The charge retention properties are shown in Fig. 4 in which charge potential in volts (V) is plotted against time in hours (H). Graph C shows the property of an electret device 10 shown in Fig. 2 whose outer plates 26 and 28 are made of conductive material or metal. On the other hand, graph D shows the property of an electret device 10 shown in Fig. 2 whose outer plate 28 is made of a non-conductive material, for example ABS (acrylonitrile-butadiene-styrene) copolymer. The charge potential of graph C is maintained at almost same as the value at the time of its fabrication, for a long time. Although the charge potential of graph D gradually decreases after the time of its fabrication, the charge potential reaches a steady state about 24 hours afterwards. Then, both of the charge potentials remain at the steady states for a very long time.

Furthermore, an electret device 10 of Fig. 1 or Fig. 2 whose outer layers 22 and 24 or plates 26 and 28 are of conductive material is

easily capable of having its decreased surface charge increased by means of supplying high potential voltage between conductive layers 22 and 24 (Fig. 1) or outer plates 26 and 28 (Fig. 2) because dielectric layers 18 and 20 are repolarized by the high potential voltage.

Fig. 5 shows sectional view of a modified embodiment of an electret device 10, comprising a plurality of electret elements, for example four, electret elements 12*a*, 14*a*, 12*b* and 14*b* which are stacked together. Electret elements 12*a* and 12*b* are negatively polarised and electret elements 14*a* and 14*b* are positively polarised. Dielectric layers 18*a* and 20*a* of the first and second electret elements 12*a* and 14*a* face each other. Conductive layers 24*a* and 22*b* of the second and third electret elements 14*a* and 12*b* face each other and dielectric layers 18*b* and 20*b* of the third and fourth electret elements 12*b* and 14*b* face each other. Conductive layers 22*a* and 24*b* of the first and fourth electret elements 12*a* and 14*b* are located at opposite ends of the electret device 10.

Electret device 10 of Fig. 5 has a very high surface charge potential of nearly four times of that of an individual electret element.

CLAIMS

1. An electret device, comprising:

a first electret element comprising a negatively polarized dielectric layer and a conductive layer; and

a second electret element comprising a positively polarized dielectric layer and a conductive layer, which second electret element is stacked with said first electret element with the dielectric layers facing each other.

2. An electret device according to claim 1, wherein it further comprises an intermediate plate between said first and second electret elements.

3. An electret device according to claim 2, wherein said intermediate plate comprises conductive material.

4. An electret device according to claim 2, wherein said intermediate plate comprises non-conductive material.

5. An electret device according to claim 2, wherein said intermediate plate comprises semi-conductive material.

6. An electret device, comprising:

a first electret element comprising a negatively polarized dielectric layer and a conductive layer;

a second electret element comprising a positively polarized dielectric layer and a conductiv lay r, which second electr t el ment is stacked with said first electret lement with the conductive layers facing each other directly; and

out r plates stack d on said first and second electret elements r spectively, in which at least one of the outer plates comprises conductive material.

7. An electret device, substantially as herein described with reference to Fig. 1, or Fig. 2, or Fig. 5 of the accompanying drawings.

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